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Unmanned Aerial Vehicles (UAVs) on the Future Tactical Battlefield – Are UAVs an Essential Joint Force Multiplier?

A Monograph
by

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This monograph identifies and examines the criterion for the acceptance of unmanned aerial vehicles (UAVs) as tactical joint force multipliers. The concept for their use rests on historical validation as well as the realization that force multipliers with joint applicability appropriately reflect new political and fiscal realities. Current and near term UAV technology offers some very needed capabilities to aid success on the future tactical field of battle.

The monograph investigates the historical use of UAVs, specifically concentrating on Israeli use in the 1982 Lebanon Air War and United States use during Operation DESERT SHIELD and DESERT STORM. Historical examples serve to demonstrate UAV capability across five broad mission areas: reconnaissance, surveillance and target acquisition; targeting; deception; electronic warfare; and command and control.

Finally, the monograph discusses the current status and projected future of UAVs. Discussion in this area surrounds the recently created UAV Joint Program Office, cost-effectiveness of UAVs, and institutional inertia.

Research shows that it would pay the United States to invest in the flexibility of UAVs. They are proven in combat, cost-effective, adaptable to future technology, and are a logical choice to multiply combat force on the future battlefield. Overcoming organizational resistance, not technology, is the major barrier to UAV acceptance.

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ABSTRACT

UNMANNED AERIAL VEHICLES (UAVs) ON THE FUTURE TACTICAL BATTLEFIELD - ARE UAV's AN ESSENTIAL JOINT FORCE MULTIPLIER? By MAJ Ronald L. McGonigle. USAF, 58 pages.

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> We have just won a war with a lot of heroes flying around in planes. The next war may be fought with airplanes with no men in them at all. It certainly will be fought with planes so far superior to those we have now that there will be no basis for comparison. Take everything you've learned about aviation in war and throw it out of the window and let's go to work on tomorrow's aviation. It will be different from anything the world has ever seen.[1]
>
> US. Army Air Forces General Hap Arnold

General Arnold's speech, delivered 2 September 1945, carries with it a vision that is as valid today as it was 47 years ago. Though far from conducting total aerial combat without men, the United States is on the brink of accepting pilotless air vehicles as essential combat force multipliers on the battlefield. Since World War II, these unmanned vehicles have shown steadily increasing use on the battlefield. This increased usage is only outpaced by the unmanned vehicle's performance and technological promise. It is this performance and promise that must deliver within the context of newly defined armed services and, more importantly, on the future field of battle.

The future defense structure of the United States will be smaller and will operate on a constrained and closely watched budget. In view of this reality, national and allied expectations still require the United States to maintain a credible and unbeatable force. This is a very difficult problem, exacerbated by an undefined threat and the probability of a non-linear battlefield.

How will the defense structure solve these problems with less force and fewer dollars and still placate a nation and its allies who expect rapid victory with few casualties? This essay examines the capabilities of unmanned aerial vehicles[2] (UAVs) to provide a small piece of the solution to the tactical problems

linked to wartime expectations. Specifically the essay will attempt to answer the question- are UAVs an essential joint force multiplier for the future tactical battlefield?

Unmanned platforms have explored the planets gathering and relaying data vital to space exploration. They have been used in a diverse number of fields, from ocean research to atmospheric sampling with excellent results.[3] Since World War II they have been used on the battlefield with increasing success.

UAVs can penetrate enemy defenses to provide reconnaissance, laser designate targets, perform bomb damage assessment (BDA), detect chemical agents, and perform a myriad of other missions that are dangerous for manned platforms. They can provide still photos, electro-optical (EO), infrared (IR), and radar imagery. Their inherent stealth characteristics allow them to loiter above a target unseen, while performing electronic warfare or communications relay missions.[4] Their versatility is unmatched as a combat multiplier. Why, despite UAV demonstrated capability, have battlefield commanders not endeared themselves to an approach that completely integrates them onto the battlefield?

To be an effective force multiplier and to win acceptance by commanders, UAVs must adequately satisfy the criteria listed in the following table. The criteria are representative of the shortfalls of UAVs in combat operations. Whether or not UAVs satisfy each criterion is addressed throughout the essay and in a completed table (Table 2) at the conclusion of the essay.

CRITERION FOR THE ACCEPTANCE OF UAVs			
	MEETS JOINT SERVICE EXPECTATIONS		
	YES	NO	CURRENTLY BEING ADDRESSED
UAV System controlled by commanders from battalion to corps level or service equivalent			
Commanders have access to UAV data gathered in their area of operations in real-time or near-real-time form			
Proposed systems are capable of interchangeable or multiple payloads			
Proposed systems satisfy multi-service requirements			
Survivable in a high threat environment			
Cost-effective			
Adaptable to off-the-shelf and near future technology			
Easily mobilized with few assets			
Easily maintained			
Have role flexibility			

Table 1

To fairly represent current UAV capability against the established criterion, this essay will discuss the effect of UAVs as an essential joint force multiplier.

Although UAVs were first used in World War I, their operational impact was not realized until World War II. In 1939 the Germans developed the Fiesler 103, better known as the V-1 Buzz Bomb.[5] From June 1944 through March 1945 the Germans launched over 10,500 V-1 UAVs against England. Over 2500 of the V-1s stayed mechanically intact, survived the British defenses, and went on to hit their targets. The UAV raids resulted in 14,665 casualties.[6]

Both German and American World War II UAV programs suffered in one major area-- accuracy. The USAF converted damaged B-17s and B-24s into UAVs. A pilot would launch the bomb laden aircraft and then bail out once over the continental coast. The UAV would then be remotely guided to a large target area.[7] The problem of

inaccuracy represented a serious flaw in the UAV concept, a flaw that would plague the program up through the Korean War.

The 1960s ushered in demand and new technological capability for UAVs. On 1 May 1960, a U-2 reconnaissance aircraft piloted by Gary Francis Powers was shot down over Russia. The political turmoil caused by the shootdown and Power's subsequent capture forced President Eisenhower to cancel U-2 missions over Russia and China. The political embarrassment caused by the incident and the need for reconnaissance information heightened White House interest in a UAV project, code name "RED WAGON." However, Department of Defense (DOD) inertia slowed project progress and it did not become fully operational until August 1964.[8]

Operational reconnaissance UAVs demonstrated their value in flights over China and Vietnam in the late 1960s and the early 1970s. Strategic Air Command (SAC) used them to obtain high quality photographs of military facilities and troop movements in China. This clearly demonstrated the benefit of using advanced UAVs over politically sensitive areas.[9] If lost over the target country, the United States could claim navigation or system problems, but when successful, the UAV captured invaluable information without risking a pilot or possible national embarrassment. Program success over China carried over into the Vietnam War.

A Soviet modeled integrated air defense system (IADS) in North Vietnam accounted for 90 percent of the Americans who became prisoners of war.[10] Due to increased pilot risk, DOD relied on a

highly classified UAV program as a substitute for manned reconnaissance over heavily defended North Vietnamese targets.

The program, code name "BUFFALO HUNTER" flew over 3000 sorties with an attrition rate of less than 10 percent. Their speed and small size allowed them to navigate through heavy enemy defenses while successfully performing pre-strike reconnaissance, bomb damage assessment, and photography of unsuspected future targets.[11] Success brought expansion to mission areas and UAVs began flying limited missions in leaflet dropping and collection of electronic intelligence (ELINT). The program demonstrated and proved its strengths and potential, but it also demonstrated its weaknesses.

UAVs were very survivable in a high threat environment. One reconnaissance UAV flew almost 70 missions over heavily defended targets in North Vietnam before it was brought down by anti-aircraft artillery (AAA) fire.[12] However, the major problems with funding prevented identified and needed design improvements. Improvements were needed to increase capability and mission performance. The majority of missions failed because of system malfunctions or fuel shortages, problems that would have been easily overcome with proper funding.

As the war waned, the Air Force lost interest in UAVs. In 1973 the Air Force's position and Nixon's political agreements with China led to a shutdown the of the reconnaissance UAV program that had been so successful over China and Vietnam. UAVs headed for storage, but the technology that had made them successful carried over into programs that would improve the new family of

laser and optically guided weapons. Although lessons would be lost by the United States, they would be garnered by the Israeli military. During the 1973 Yom Kippur War, the Israeli Defense Force (IDF) introduced pilotless aircraft to the battlefield.

During this war the Israeli Air Force employed pilotless aircraft as a first wave of an aerial attack against Arab forces. The UAVs fooled radar operators and defense systems. The ruse caused Arab defenses to expend their surface to air missiles (SAMs) and AAA against the UAVs, giving the second wave of manned aircraft a chance to penetrate the SAM and AAA defenses during a period of reloading.[13] The result was a successful Israeli attack with few losses to manned systems. Due to their potential to save valuable aircraft and invaluable aircrew lives, the Israelis developed a high regard for UAV use. Success with pilotless vehicles during the 1973 Yom Kippur War inculcated a desire in the IDF to further its research into uses for UAVs on the battlefield. This research would payoff handsomely during the IDF's 1982 conflict with Lebanon.

The use of UAVs during the 1982 Lebanon conflict between Syria and Israel represents one of the clearest examples of why and how UAVs should be employed in the tactical arena. The initial 48 hours of operations in this conflict known as Operation Peace for Galilee "constitute a brief but full scale conventional war that had enormous, perhaps unparalleled, implications for the future of major war."[14] The IDF employment of western military hardware against a force employing Soviet equipment and tactics makes the conflict a highly relevant study for those who would

employ similar western equipment against forces based upon the Soviet model. This massive combined arms assault, designed to destroy the PLO as a military force and neutralize Syrian combat forces, began on 6 June. The air portion of the campaign started three days later at 1400 hours on 9 June.[15]

For over a year prior to the battle, the Israeli Air Force (IAF) had been using unpiloted vehicles and reconnaissance aircraft to collect photo and ELINT data of Syrian SA-6 SAM locations in the Beka'a Valley. The long collection period and the data provided the IAF with a highly accurate threat picture, time for extensive planning, and time to tailor a force ideal for the upcoming battle.

The IAF used a four-phased operation against the Syrian IADS. The first phase called for the launching of inexpensive decoy UAVs into the Syrian IADS. The goal of this several hour phase was to keep Syrian defenses in constant suspense while wearing down operators.[16] The decoys saturated Syrian radars, and their operators, showing poor target discrimination and firing discipline, massed launched SAMs and AAA against the UAVs. This action triggered the second stage.

Once SAM radar positions were positively confirmed, by UAV and other EW collectors, they were engaged. The northern radar sites were neutralized by F-4 electronic counter measures (ECM) and by fire in the form of SHRIKES, Standard ARMs and MAVERICK missiles. SAM radar sites in southern Beka'a Valley were attacked by artillery and the Israeli Ze'ev ("Wolf") ground launched missile.[17] This use of passive and active electronic warfare (EW)

measures to shut down or destroy the Syrian IADS was augmented by UAVs programmed to detect AAA radars, such as the Gun dish radar on the ZSU-23-4 *Shilka*. Once the UAV detected the radar signal it would perform a kamikaze dive into the emitter.[18] With the Syrian IADS in total disarray, the IAF launched the third phase of the operation-- undetected penetration of manned strike aircraft.

F-4 and F-16 aircraft easily penetrated through large gaps in the Syrian integrated defense to kill the remaining SAM radar vans and SA-6 launchers with laser guided and standoff munitions. The fourth and final phase of the operation suppressed the remainder of the shocked Syrian aerial defense systems with cluster bomb units (CBUs) and general purpose bombs.[19] The highly successful phased operation reportedly took only 10 minutes to execute and resulted in the destruction of 17 out of 19 SA-6 sites and several SA-2 and SA-3 sites in the Beka'a Valley.[20]

With the Syrian IADS shut down the IAF enjoyed immunity from ground defenses while it engaged in the fight for air superiority. The IAF, once again, used UAVs to augment the fight. UAVs were employed over three major Syrian airfields to monitor Syrian fighter MiG aircraft activity. As soon as the MiGs taxied for takeoff the UAV detected them and relayed the real-time photo information to E-2 AWACS aircraft. The AWACS aircraft then vectored Israeli fighters to the unprepared and unsuspecting MiGs. The UAVs also contributed the confusion of MiG aircraft by helping to jam MiG ground controlled intercept (GCI) communications frequencies.[21] Robbed of this communication link the airborne MiGs were confused and seriously disoriented, making them easy

prey for Israeli fighters. During this encounter the IAF shot down 23 Syrian MiG fighters. By the end of July, using manned aircraft augmented by UAVs, the IAF would lose only 2 aircraft to AAA fire while destroying 85 Syrian MiGs and 29 SAM sites.[22]

During the Lebanon campaign the UAVs provided continuous video coverage for the IAF strike commander, collected EW information, lased targets for aircraft employing laser guided munitions, precisely directed artillery fire onto threat locations, jammed communication frequencies, and provided real time BDA. UAVs were key force multipliers for this operation, offering an example to other nations of their validity and 'coming of age' to the tactical battlefield.

The UAV represented another strengthening link in the bonding of air warfare to land warfare. They provided commanders an array of missions to assist in intelligence collection, movement, and engagement. Though the Lebanon air campaign was severely limited in scope and the Syrians proved to be poorly organized, Western, Soviet, and Soviet satellite nations quickly realized the benefits of using UAVs in modern warfare. Many Western nations, including the United States, began taking a renewed interest in UAVs.

Historical success as combat force multipliers represent the mark of UAV employment in combat operations. Nonetheless, commanders still have many questions as to their capabilities and limitations. What missions can they adequately perform or augment? What do they offer to each component of the military and can they be organized for mutual joint benefit? How can current

technology further improve their contribution to the battlefield? Will they have an impact on the battle field of the future? These are but a few of the questions being asked by the military establishment, but they are among the most important. UAVs, in order to be an essential force multiplier, must answer these questions and have utility on the battlefield of the future.

Several principal factors: technology, reduced force structure, diffusion of Soviet arms and tactics, smaller budgets, and focus on regional operations, have begun to redefine the battlefield. These principal factors will bring several important changes to the spectrum of conflict, including a change in the paradigm for the conduct of combat operations.

New political realities, fiscal realities, and technological change will create a less linear and more expanded battlefield. Tactical and operational commanders will have to accept more risk as the battlefield takes on this nonlinear look that leaves large gaps between forces. "Unlike operations on a linear battlefield, the integrated and mutually supporting activities inherent in nonlinear operations occur on *one extended battlefield* and may occur separately in space and time."[23] This is a battlefield with widely separated forces, a fact that blurs or sometimes invalidates the concept of the traditional front line. Linear operations will still occur, but only at times and places beneficial to operations.

Successful combat, on a battlefield containing more depth and breadth, will require commanders who can orchestrate operations in three dimensions. Operations of this nature seek to

avoid the attrition nature of linear operations, orient on the enemy rather than terrain, and require commanders to create and exploit conditions to use the inherent power of operational maneuver.[24] Commanders will use all the tools they have to affect operations on the extended battlefield.

Synchronized linear and nonlinear operations on the extended battlefield accomplish strategic and operational goals. The extended battlefield, depicted in Annex A Figure 1, serves as a model for operational planning. Operations in the Joint Intelligence and Air Attack Area seek to identify strategic targets and destroy them in an effort to affect operations across the tactical, operational and strategic level.

The Joint Battle Area is where airpower synchronizes with the Army's deepest reaching land systems to affect the enemy, mainly at the operational and tactical level. A primary goal at this stage is the maximum gathering of intelligence throughout the depth of the battlefield. Corps commanders will use UAV sensors and reconnaissance capabilities to see the battlefield out to 400-500 km.[25]

Land and air operations in the shaping area focus on locating the enemy and then setting the conditions for decisive battle in the Close Battle Area. Long-range fires focus on separating the enemy in space and time. UAVs provide the tactical commander observation of the enemy; communications relay to lateral, subordinate and higher commands; targeting of the enemy for fires; and BDA of those fires. During decisive operations

UAVs provide intelligence on gaps in enemy defenses that can be exploited by maneuver forces.

In Desert Storm the Army used UAVs for route reconnaissance for the AH-64 attack helicopter. Pilots used the UAV imagery to familiarize themselves with terrain, defenses, and target locations just prior to flying the attack mission.[26] UAVs offer the commander a number of important capabilities that remarkably speed up the see-decide-act-assess process. Through this continuous process, combat power is decisively brought to bear upon the enemy.

During operations in the Joint Intelligence and Air Attack Area and the Joint Battle Area maneuver forces can be held in the Staging, Logistical, and Dispersal Areas until committed to operations. Throughout the depth and breadth of the battlefield, UAVs have assiduous and overlapping missions. After defeat of the enemy, combat forces will disperse back to logistical areas for reconstitution. UAVs will perform route reconnaissance, maintain enemy surveillance, provide BDA, and conduct deep operations for the next fight.

The extended area model, depicted in Annex A Figure 1, is a planning tool to aid the operational commander in synchronizing complex three-dimensional warfare. Areas are not fixed in relation to each other but are created and modified as the plan dictates. This means that several of these models may be in action at any given time with the critical link being real-time or near real-time information. UAV use in Desert Storm demonstrates that they can play a current role in the close battle and shaping

areas[27] and newly developed prototypes promise to enhance operations across the spectrum of the future extended battlefield. The question arises as to whether UAVs can survive the anticipated and extremely hostile environment to meet the needs of commanders across this spectrum.

Many regional foes have adopted hybrids of the Soviet model. Soviet weapon systems are inexpensive and easy to come by due to the Russian society's reliance on export of weapon systems to support a weak economy. Regional armies, such as Iraq, Iran, and China, are taking advantage of lucrative prices to bolster their own military capability. This offers disadvantages and advantages to the United States. The primary advantage is the knowledge gained over the Cold War era of Soviet doctrine and of the capabilities of Soviet systems. This provides a starting point for intelligence communities to figure out how Soviet systems will augment existing regional systems. The primary disadvantage is that many regional powers will have the additional lethal capability of these systems. Additionally, most regional powers do not have to contend with the immense fronts presented in the Soviet model, so they are able to array an in-depth Soviet style IADS with fewer systems. The Iraqi defense structure is one such model.

The Iraqi IADS uses a mix of defensive systems, primarily Soviet, to create their integrated air defense system. This IADS is arrayed in the fashion of the Soviet model depicted in Figure 2 of Annex A. Their system contains the qualities of depth and ovelap found in the Soviet model.

The model's depth and overlap, in both range and altitude, will become more lethal as the Russians sell off newer model SAMs, AAA, and aircraft. This air defense system is characterized by layered air defenses containing large numbers of sophisticated ground-to air and air-to-air systems networked by rapid and efficient command, control, and communications systems.[28] Characteristic design allows it to flow with the moving ground force as well as defend fixed command and control, logistics, industrial, and communications locations.[29] The increasing lethality of this IADS equates to increased risk for manned missions. Opposition counters are to send more numbers of scarce manned assets against targets, decrease the risk with advanced technology, or find an acceptable substitute for high risk missions.

Larger mission packages would work in the short term but the losses and cost in crew and equipment would eventually be too high. The U.S. military has always been enamored with new technology and that is the path it has taken to counter new threats on the battlefield. However, new technology increases the cost of survivable manned systems.

A RAND Corporation study estimated that a USAF budget equivalent to the actual dollars available to the service for aircraft procurement in 1972 would buy less than ten aircraft by the year 2000 and only one aircraft by the year 2020.[30] This is an unacceptable position for the military. Flying a $25 million dollar aircraft, such as the proposed RF-16, into a highly technological and integrated air defense system to accomplish a

task that can be accomplished by a UAV costing only thousands of dollars is neither logical nor economically feasible.

Relatively low cost UAVs demonstrated their ability to circumvent this potent air defense system in Lebanon and even more recently in the Gulf War. The UAVs ability to successfully operate and survive in a modern integrated air defense system provides a viable alternative to the critical problems of manned aircraft attrition and survivability in several key mission areas.

One of the biggest challenges of the future battlefield will be the fusion of intelligence assets, target acquisition assets, and the commander's understanding of the current battle situation. Carrying varying payloads, UAVs can perform a number of missions to meet this challenge. The information depicted in Annex A, Figures 3 & 4 represents service component desires by correlating missions with payload category.

Today's UAV mission capabilities range across five broad mission areas: reconnaissance, surveillance and target acquisition (RSTA); targeting; deception; electronic warfare; and command and control. UAVs that perform these missions are procured as complete systems. A system contains the UAV platform(s), mission payloads, ground support equipment, and data links.[31] Current UAV systems can perform all five of the mission categories but the primary focus has been in the RSTA mission area.

RSTA missions obtain information about an area, enemy or potential enemy. This information is collected photographically, visually, electronically, acoustically, and by a number of other

methods.[32] After collection, information is matched with an appropriate target response.

Information is of critical importance to the tactical commander, especially on a non-linear battlefield. Timely identification is essential in order to give commanders time to mass combat power at the decisive time and place. United States Marine Corps UAVs in Desert Storm proved their ability to provide timely information.

Marine Task Force Ripper of the 1st Marine Division used a UAV to foil an Iraqi tank battalion counterattacking force located at the Kuwaiti International Airport. The UAV detected the force at the north end of the airfield and relayed real-time imagery of the enemy force to the Task Force Ripper command vehicle. The enemy force was targeted and engaged by naval gunfire and air attack before it could do any damage to the Marine Task Force.[33] UAV presence in the Gulf allowed commanders to experiment with their integration on the battlefield. A result of that experimentation was the symbiotic relationship developed between the Pioneer UAV system and the Joint Surveillance and Target Attack Radar System (J-STARS).

J-STARS used a synthetic aperture (SAR) radar and moving target indicators (MTI) to locate suspected maneuvering enemy ground targets. Upon detection, J-STARS opened an electronic link to a United States Marine Corps Pioneer UAV that flew to the location to provide a positive and real-time verification of enemy forces. The relationship was so successful that one of the three Marine Corps Pioneer UAV companies was used almost exclusively in

this verification role.[34] This RSTA application served the tactical command environment by providing a direct contact between ground commanders and acquired intelligence.

Ground commanders need timely intelligence and the United States Air Force is one of the Army's primary deep tactical intelligence collectors. The anticipated increased tempo and intelligence requirements of the non-linear battlefield demand that acquisition and assessment of intelligence information be collected in real-time or near-real-time fashion. The current relationship and structure does not support these requirements. Currently, complete reports of targets flown by tactical Air Force assets do not reach the requesting ground commander until 12-24 hours after landing.

The problem is exacerbated by the fact that the Air Force is phasing out the RF-4C, its primary tactical intelligence collector, before replacement systems can be sufficiently fielded.[35] During Operation Desert Shield and Desert Storm the Air Force had a requirement for six squadrons of RF-4C reconnaissance aircraft but only fielded one and a half squadrons. The result was overtasking of assets and a marked shortage of tactical intelligence collection. Aircrew were put at risk as they attempted to image over 30 targets per mission instead of the normal 3-4.[36]

Due to the shortage of tactical intelligence collectors, existing UAVs were employed to fill the collection void. The Army, Marine Corps, and Navy recognized the problem early on and solved it by employing off-the-shelf and somewhat outdated

Pioneer, Pointer, and Ex-Drone UAV systems. The successes of these systems testify to their versatility in not only acquiring tactical intelligence, but also in performing other critical missions.

UAVs have revolutionized the role of target designation and support for naval gunfire. Naval operations in the Gulf War included UAVs in constant overwatch of USS Missouri and USS Wisconsin 16-inch gun operations. Fewer rounds were expended and weapons effectiveness was significantly increased due to UAV use. Gunners aboard the battleships used televisions linked with UAVs to monitor 1-ton shells as they impacted targets over 20 miles away. The gunner then used a light pen, connected to a computer, to draw a line between the impact point and the intended target. The computer calculated the desired correction, sent it to the gun which fired a corrected round. After impact on the target, instant BDA was relayed back to the ship informing gunners of target destruction status.[37] The use of UAVs in this capacity increased weapon effectiveness, negated the need for ground spotters, reduced collateral damage, and freed manned reconnaissance platforms for other missions.

Closely paralleling the naval gun support mission is UAV targeting. The main difference is that targeting is an active mission whereas naval gun spotting is a passive mission. The effectiveness of laser targeting was proven during the Lebanon Air War, where UAVs targeted for both aircraft and field artillery. UAVs are best suited for this mission because laser designation is more accurate when using a high angle of incidence. UAVs obtain

these desired angles from over flight of the target or from high orbits over the target area.[38]

The laser beam from the UAV to the target acts as a guide for laser guided munitions such as the Army's copperhead artillery round, the Hellfire missile, and the Air Force's family of laser guided munitions. The munition's guidance system 'captures' the laser beam and follows it directly to the target. UAV lasing increases weapon effectiveness while decreasing risk to the aircrew and ground lasing teams that normally perform this task.

Although UAVs are at more risk over or orbiting the target, their inherent stealthy characteristics allow them to perform this task and survive in high threat areas. Through interviews with Iraqi prisoners of war, it was determined that enemy soldiers could not even see UAVs at altitudes of 5000 feet or greater.[39] UAVs can perform their lasing mission virtually undetected, relay BDA results, and then relocate to base or another target. Despite proven combat effectiveness and available off-the-shelf technology, the United States did not have an operational UAV that could laser designate targets during the Gulf War. They did, however, have operational UAV decoys.

The United States use of UAV drones for aerial deception came as a result of a hard lesson learned in 1983 by the Navy in the Beka'a Valley. Twenty-eight United States Navy aircraft were launched against Syrian targets in Lebanon. The costs, resulting from the mission, far outweighed any operational gains. The mission ended with the destruction of two United States aircraft and damage to another. As a result, one aviator was killed and

another captured. The Navy had to fall back on blind 16-inch shelling from guns on the USS New Jersey because it could not get ground observers into the target area. Naval gunfire was not verified from the air because the Navy was reluctant to use their $40 million dollar per copy reconnaissance F-14s in an area where they had already lost two aircraft.[40] Embarrassed by operational shortcomings and pressured by public opinion, the United States reconsidered its policy in Lebanon and ended operations there. The United States had failed to learn critical lessons from the Israeli conflict with Lebanon just one year earlier.

The unfortunate outcome of the 1983 naval operation in Lebanon led to the Navy's interest in developing and procuring a tactical air launched decoy (TALD). TALDs are UAVs used to deceive enemy defenses. The result is two-fold: enemy defenses expend expensive SAMS and AAA on unmanned aircraft; secondly, enemy radar sites reveal their positions to weapons poised to destroy them. With enemy air defense radar sites destroyed or shut down, defenses cannot accurately guide SAMs and AAA against penetrating aircraft.

U.S. Marine and Navy pilots used these unmanned gliders in the Gulf on an airfield raid, near heavily defended Baghdad, on day one of the air campaign. TALDs masked the manned strike aircraft by overloading Iraqi SAM and AAA radar sites with more targets than they could handle. Once enemy radar sites revealed themselves, F/A-18 aircraft fired high speed anti radiation missiles (HARMS) at them. During the time of this raid, over 200

HARMS were in the air at one time, following a screen of TALDs into Baghdad.[41]

Manned aircraft launch TALDs along a route separate from the route of strike aircraft. HARM equipped aircraft monitor the TALDs and enemy radar response. An electronic combat specialist in the Gulf predicted a doubling in HARM effectiveness against enemy radar sites. Usually only 10-15% of HARMS find their target. However, when used in conjunction with TALDs that ratio could increase to 25-50%.[42] As a result every suppression of enemy air defense (SEAD) flown by the Marine Corps incorporated TALDs. Use of UAVs in the Gulf, as decoys, were not strictly limited to Navy and Marine Corps flight operations.

The United States Air Force 868th Tactical Missile Training Group, formerly a Ground Launched Cruise Missile (GLCM) unit, was ordered to report to a location in California. After arrival, they were redesignated as the 4468th Tactical Reconnaissance Group and given the Desert Storm mission of operating Northrop's BQM-74C aerial target drones, code named SCATHE MEAN.[43]

Sometime in October, the 4468th was secretly flown to Saudi Arabia where it continued to train. By Thanksgiving, the 4468th had reduced set-up time from 9 1/2 hours to 1 1/2. Its mission was to ground launch BQM-74s, on 17 January 1991, in front of United States strike packages that were flying against targets at H-2 and H-3 airfields and against targets in and around Baghdad.[44] The decoys arrived on schedule, just behind the F-117 raid and just ahead of the strike packages. United States Air Force F-4G "Wild Weasel" aircraft launched HARMS against the deceived radar sites

that were locked onto BQM-74 drones. In two days Iraqi air defenses were shattered and the 4468th had completed its mission.[45]

The 4468th mission was so successful that the Iraqis did not even know that they had been duped. They reported a large number of aircraft shot down during that raid, but almost every claimed kill was a TALD or Air Force drone. The use of UAVs as decoys played a major role in reducing losses to coalition aircrew and platforms.

The use of UAV decoys in tactical operations is an excellent example of their use as joint force multipliers. The initial airstrike on 17 January combined Navy TALDs and Tomahawk cruise missiles with Air Force BQM-74s. This employment of lethal and non-lethal UAVs complemented highly successful coalition airstrikes against critical targets deep within Iraq. RSTA, targeting, and deception missions are essential, but controlling the electromagnetic spectrum will be critical on the future battlefield.

> The next major war will be won by the side which best uses the electromagnetic spectrum. Electronic warfare...is a field where changes are occuring rapidly, where nobody really knows what will happen...a subject which all the major powers shroud in shadow, an area as dark and secret as it is vast and diffuse.[46]

Today's military forces depend upon electronics for the employment of modern weapon systems and the command and control of forces. This dependency makes all forces vulnerable to actions that would control or manipulate the electromagnetic spectrum.[47] Electronic combat properly integrated in time and space is the

sine qua non of modern warfare, vital to aerospace and surface warfare and to the success of theater campaigns.[48]

The ability to exploit the electronic spectrum significantly increases the effectiveness of combat forces. Electronic warfare employed in conjunction with maneuver forces produces a cumulatively disastrous effect on the enemy's capability to wage war.[49] UAVs have the capability to exploit the enemy's electromagnetic spectrum and thus increase the combat effectiveness of our forces.

Electronic Warfare (EW) exploits, disrupts, and deceives the enemy command and control of forces and weapons while protecting friendly capability. EW has three categories: EW support measures (ESM), which perform the functions of interception, identification, and location of enemy emitters; electronic countermeasures (ECM), which disrupt enemy use of the electromagnetic spectrum; and electronic counter-countermeasures (ECCM), which protect friendly use of the spectrum.[50] Today's UAV payloads are best suited to support the ESM and ECM missions.

A significant capability of UAVs is collection of imagery intelligence (IMINT) and signals intelligence (SIGINT), which was demonstrated by Israeli UAV operations in Lebanon in 1982 and by U.S. operations during Desert Shield and Desert Storm. SIGINT and IMINT intelligence acquired by UAVs during these operations played a key role in painting a picture of how enemy forces, their defenses, and their command and control structures were deployed.

UAVs with EW payloads used in conjunction with manned platforms increases the lethality and survivability of those manned assets. In the absence of effective electromagnetic counters, air power can come off a poor second to integrated air defense systems in terms of net operational losses versus net gains.[51]

ESM UAVs not only listen for electronic signals from enemy equipment but can determine the characteristics and location of transmitting equipment. Additionally, they can analyze data, encode it, and data link the information to airborne or ground command posts. UAVs used in 1982 by Israel is a prime example.[52] They are ideal for this mission because they can loiter and collect ESM and IMINT information on a heavily defended enemy, often undetected. Pushing this capability down to lower echelons allows those commanders to develop a timely intelligence picture of their area of operations without reliance on national or theater assets.[53]

Information gathered from UAV ESM missions identify the locations of enemy defenses and "fingerprint" their electronic signatures. With this information, defense sites can be shut down by lethal or non-lethal means. Ground or air assets can destroy the defense sites or ECM packages carried by UAVs or manned platforms can electronically jam defense radar sites or the communications that control them.

Ground and manned platforms usually perform jamming functions for combat operations. Ground systems are hampered by range and numbers of available jammers, while the drawbacks for

manned air platforms, such as the EF-111, EC-130, EA-6 and F-4G, are cost, risk and numbers of available assets. Manned EW platforms are designed to stand-off from a target and perform their mission. This reduces the number of required aircraft and reduces crew risk, but requires that these aircraft jam large areas. To do this effectively requires a great deal of electrical power.

Increased power requirements and the requirement to jam a large area operating many frequencies increase system complexity and drive up platform costs. UAVs offer a low cost alternative to expensive manned platforms and, at the same time, extend the range and jamming capability of ground forces.

The power required to effect target antennae varies according to the square of the range, provided the jammer has line of sight to the target. Power requirements for a UAV one mile from a target antenna would need to be only one-hundredth that of a jammer 10 miles away and only one-ten-thousandth that of a jammer 100 miles away.[54] Because UAVs can operate close to the jammed source their power requirements are low and their payloads focus on select frequency bandwidths. Reduced costs and increased capability are the payoffs of using UAVs in this capacity. Similarly, ground commanders increase range in their area of operations at reduced risk. EW UAVs increase area coverage of existing air and ground platforms and can be employed in areas deemed too risky for manned assets.

Closely aligned with EW payloads for UAVs are payloads that compliment command and control. During the Gulf War, they

provided ground, naval, air, and marine commanders at all echelons a continuous view of their areas of operations, an unprecedented advantage for battlefield management.[55] The timeliness of the information UAVs provide is crucial for the rapid decision requirements of the future battlefield. With timely information, commanders decide when and where to mass forces for decisive operations. UAVs in spotting, lasing, and BDA roles serve to partially penetrate the fog of war and to improve the chance for success. Near real-time feedback from UAVs frees decision makers from some of war's uncertainty.

The endurance qualities of UAVs allow them to act as a force multiplier in the role of a communication relay platform. Relay UAVs configured for communication functions will augment ground forces by negating the need for ground re-transmission sites. Future plans for UAVs include a high-altitude, long endurance (HALE) UAV whose payload will provide a communications relay capability. Design characteristics permit the HALE to fly above 65,000 feet and stay aloft for several days.[56] A HALE UAV will cover a large part of the theater and will free proposed corps and division UAV assets for other missions. The future of UAVs to effectively augment joint operations in the five discussed mission areas, as well as other mission areas, lies within the purview of the UAV Joint Program Office.

In 1988 Congress directed the Department of Defense (DOD) to consolidate the management of DOD non-lethal UAV programs into one area. The program is currently under the management of the UAV Joint Project Office (UAVJPO) which works joint acquisition of

UAVs through the Defense Acquisition Board (DAB) and prepares the annual DOD UAV Master Plan.[57] The UAVJPO was created to eliminate wasteful duplication efforts among services. The focus of the program is to develop and procure systems for joint service use.

The UAVJPO mission is to expeditiously field UAV systems that provide significant tactical advantage to operational commanders. The 1992 Master Plan currently includes six UAV projects: Very Low Cost (VLC), Close Range (CR), Short Range (SR), Vertical Takeoff and Landing (VTOL), Medium Range (MR), and Endurance (HALE). UAVJPO strategy revolves around a family of UAV systems (Annex A, Figure 5), with the SR system representing the baseline for maximizing interoperability and commonality among five of the six projects.[58] The MR system has unique requirements and falls outside of the family concept.

UAV system designs focus on interoperability so maximum benefit will be gained in a joint war fighting arena. They will be designed to be integrated in a manner that allows for interface between UAV family systems, which include aerial vehicle payloads, data links, and ground control and processing stations. The system architecture incorporates available technology to provide a current capability but also allows room to accommodate future technology.[59]

Commonality in UAVs centers on using similar systems and payloads across the family of UAVs. Alike avionics, engines, fuel, sensors, relays, data links, ground stations, and modular payloads all serve to increase joint force enhancing qualities.

These characteristics will also drive down life cycle costs and simplify logistical support.

Joint Service requirements fall under four categories of UAVs: Close, Short, Medium, and Endurance. The VLC project is incorporated into the Close category and the VTOL falls under the SR category. Figure 6 in Annex A depicts the current Joint Service operational needs by UAV category.

CR and VLC systems reflect the need of lower level echelons such as United States Army battalions, brigades and divisions and United States Marine Corps companies and battalions. The need at this level is for a system that can perform operational needs out to approximately 30 kilometers.[60] Marines validated the CR concept during the Gulf War using outdated FQM-151A Pointer and BQM-147A Ex-Drone UAVs. Pointer and Ex-Drone operations proved to be disappointing. Line of sight limitations, sensitivity to strong winds, and lack of an on-board system to identify vehicle position hampered Pointer operations and the Ex-Drone was limited to day, fair-weather missions.[61]

Although there were limitations to these CR UAV operations, they did gather usable intelligence and enhanced combat operations. The identified shortfalls noted in Pointer and Ex-Drone operations are being corrected in the follow on VLC system.[62]

The SR UAV is the core system[63] for all potential UAVs considered for development and procurement in any family of UAV category. Systems within this category support division and corps level operations for the Army and also support Marine Air-Ground

Task Force operations. The focus here is on UAV operations out to 150 kilometers beyond the front. Naval interests in the SR vehicle range from naval gun spotting to the needs depicted in Figure 6 of Annex A.

The Pioneer UAV system used during Operation Desert Storm is in this category. Though it is an old system, it proved invaluable to Army, Navy, and especially Marine combat operations. Pioneers flew over 300 missions during the war and suffered only one loss to enemy ground fire.[64] They are scheduled to remain in the active inventory until fiscal year 1998 or until replaced by the follow-on SR UAV.[65]

The MR UAV is the only UAV being designed independently of the family concept. The project is a continuation of a joint Navy and Air Force program that began prior to the creation of UAVJPO. Program design calls for a UAV that can provide near real-time high resolution imagery of heavily defended operational and strategic targets for both services. MR interoperability and commonality design revolve around the Joint Service Imagery Processing System (JSIPS) and the Advanced Tactical Air Reconnaissance System (ATARS).[66]

JSIPS is a step in the right direction for solving the problems of timely processing and dissemination of intelligence information acquired by operational and theater assets. The system can do outdated film processing, but was developed to process data linked electro-optical, infrared, and radar imagery from ATARS suites.

JSIPS is designed to be used in the field by the Army, Navy, and Air Force.[67] Its counterpart, ATARS, is a versatile sensor package that will be carried in both manned and UAV multi-service platforms. The JSIPS-ATARS-UAV interface provides the services a needed and enhanced capability for tactical reconnaissance during a time when the numbers of manned reconnaissance platforms are being reduced in the active force. The near real-time information acquired from the MR UAV will be used at division, corps, and theater levels.

The final category is Endurance UAVs. These high altitude, long-endurance UAVs represent a comparatively low cost alternative to satellites. They have the capability to range anywhere in the world and perform a variety of high altitude missions. Surveillance, atmospheric sampling, weather monitoring, communications and data relay, and EW operations all fall within the scope of the Endurance vehicle. Comparatively, UAV costs in this category are high.[68]

Common systems in the Endurance vehicle will increase the data link and control range of CR, SR, and MR UAVs. For this reason, the few Endurance platforms that will be purchased will increase the force enhancing qualities of all UAVs.

The adaptability of UAVs to future technology is a UAVJPO design requirement. The JPO already has several technological improvements under contract. The main upgrades include modifying engines to run on a common heavy fuel, improved data link capability, laser designator, moving target indicator (MTI),

miniature synthetic aperture and inverse synthetic aperture radar (MSAR/MISAR), and improved EW payloads.

Fuel upgrades will allow UAVs to use fuel common to field vehicles, negating the need to haul and store volatile aviation gasoline. Data link upgrades will meet the need for a reliable control of data interchange between UAVs and ground control stations in high threat environments. The data links will be jam resistant and meet UAVJPO interoperability and commonality requirements.

MTI, MSAR, and MISAR systems are designed to provide all weather high resolution imagery. MTI provides imagery of moving targets using Doppler frequency shifts, but loses stationary targets in the background clutter.[69] MSAR systems, on the other hand, are enhanced radars that can detect, locate, and classify tactical stationary or moving targets. The radar can penetrate dust, clouds, and foliage.[70] MISAR uses Doppler shift imaging to lock onto, track, and image a designated moving or stationary target.[71] Combination MTI and MSAR/MISAR packages are feasible and could easily be incorporated into the MR, VTOL, and Endurance UAV.[72]

Laser designation capability is important for improving the accuracy of precision guided munitions. Lasers are very accurate and can be married to a video display that can present range and an image of the target. Lasers lose accuracy if the diameter of the radiated beam exceeds the size of the target.[73] Enhancements to current technology for UAV laser designators include increasing laser energy output to improve beam accuracy and stability.

The main advancement goal in EW payload upgrade is to develop common modular payloads for jamming, deception and ESM missions. These payloads are very complex and very expensive to produce. Commonality and modular design will drastically cut operations and development costs. Furthermore, common data links, payloads, ground programming stations, and software will decrease cost and logistical support.

All of these UAV systems and follow-on upgrades cost a great deal of money. The Department of Defense has submitted a $129.1 million dollar budget for UAVs in fiscal year 1993 and some estimates predict that the UAV market will reach $5.5 billion by 2001.[74] Is this cost justified? Are UAVs a valid purchase for the force and if so, are they cost effective?

When considering UAV systems and what they have brought and can currently bring to the tactical battlefield the answer is yes; they are cost effective investments. A United States Air Force study answered the cost-effectiveness question in the mid-1970s. The study revealed that UAVs could perform several missions flown by pilots more cheaply and more effectively. The Air Force suppressed the study.[75] A 1981 study of UAV effectiveness conducted by Congress found similar conclusions.

> There are important advantages that can be realized when circumstances allow the employment of RPVs [UAVs] instead of manned aircraft systems. These include eliminating pilot and crew losses, lowering operating costs, and increasing vehicle survivability and performance capabilities.[76]

In an environment where dollars and assets are shrinking, it is only logical to augment existing systems with combat proven and cost-effective combat multipliers. Force multipliers that can

enhance joint force capability are even a more sensible purchase. As seen in the past, UAVs used in hostile and politically sensitive environments reduce pilot risk and political embarrassment. They reduced losses during the Vietnam War and prevented the embarrassment of a Gary Powers incident when used over China.

UAVs lower mission operating costs in a number of areas. There is not a need for crew support systems such as ejection seats, oxygen systems, or armor plating in UAVs. UAV size and simplicity reap savings in design, human factors engineering, and construction costs. The proposed MR UAV and ATARS payload, designed to do the exact same mission as its manned counterpart, only costs approximately $2.5 million dollars. In comparison, a RF-16 cost approximately $25 million dollars and the Navy's reconnaissance platform, the F/A-18D, cost $36 million dollars.[77]

Cost-effectiveness is also increased by fuel efficient UAVs. A RAND study compared estimated fuel consumption's of a UAV and a F-4 performing the same mission. The F-4 consumption was estimated at 460,000 gallons compared to the UAV's 2,280 gallons.[78] Reducing theater or tactical fuel requirements has a tremendous appeal to future operations.

Aircraft have many redundant systems to ensure aircrew safety. This drives up the cost of a system and increases the complexity of required maintenance. It also increases the cost of training aircrew and maintainers. Unmanned vehicles, on the other hand, have simply designed systems that require low-level maintenance and little crew training. Because of these

characteristics, UAV personnel and training costs are much less than their manned counterparts.

The UAV is effective and survivable. It is difficult to detect and extremely hard to hit with gunfire. In 1981, the Assistant Secretary of the Army for Research, Development, and Acquisition attested to their survivability. In one test, thousands of rounds of sophisticated radar directed fire and hundreds of rounds of fifty-caliber were fired on a UAV well within range. The UAV survived the test without damage.[79] During the Gulf War, Pioneer, Pointer, and Ex-Drone UAVs flew 522 missions and 1,640.9 hours. Only one UAV was lost to hostile fire![80] Despite the cost-effectiveness of these highly capable systems, there is still a reluctance by the military community to fully integrate them onto the battlefield.

The main resistance to full integration is due to "pilot bias" and reluctance on the part of the users.[81] However, the data reflected in Figures 7A-8B in Appendix A indicate the advantages outweigh the disadvantages. The deficiencies identified by this study and current problems in meeting desired criteria are currently being addressed by the UAVJPO. These deficiencies have been corrected in follow-on prototypes that are awaiting procurement funding.

In a report to Congress the GAO found substantial resistance in replacing a known quantity (manned platforms) with an unknown quantity (UAV). The impetus for change requires that the "unknown quantity" present overwhelming evidence of effectiveness.[82] The

success of unmanned systems in Desert Storm was a large step toward that overwhelming evidence.

Accomplishments of UAVs in combat since the 1980s and up to operations in the Gulf have given the military community opportunity to evaluate the UAVs tactical merit and have provided a base from which to form a strategic measure of effectiveness. However, no matter how effective UAVs are in battle, they will be useless to the military institution if intellectual thought is not given to how to fully incorporate them into the force structure. To completely benefit from their capability will require organizational change.

Technological innovation is tied to the attempt to manage uncertainty and to meet anticipated changes in the security environment.[83] The fall of the Soviets has brought about uncertainty and has forced the United States to anticipate a new environment for conflict. In the 1980s it was recognized that computers and micro technology would revolutionize weapons of the future.[84] However, change in technology is not enough to change the way military institutions think about fighting war. Thought, organizational change directed from top leaders, and time are all required to fully implement a new innovation.

The process of change is slow, especially in large institutions. It is also clear that the acceptance of major innovations requires new career progression paths for those who specialize in the innovation and a senior leader to create the path for progression.[85] The acceptances of cruise missiles by the Navy and ICBMs by the Air Force are key examples of this pattern

of slow institutional acceptance to change.[86] Both innovations threatened roles already established in the organization and both innovations met with a great deal of resistance. However, both increased combat effectiveness.

Whether or not UAVs represent a radical change in war fighting capability remains to be seen, but the potential is surely there. Technological change in the past ten years has exponentially increased that potential. In managing uncertainty, it would pay the United States to invest in flexibility. UAVs are a flexible investment. They are proven in combat, cost-effective, adaptable to future technology, and are a logical choice to multiply combat force on the "anticipated" future battlefield. Overcoming organizational resistance, not technology, is the major barrier to UAV acceptance.

CRITERION FOR THE ACCEPTANCE OF UAVs	MEETS JOINT SERVICE EXPECTATIONS		
	YES	NO	CURRENTLY BEING ADDRESSED
UAV System controlled by commanders from battalion to corps level or service equivalent			✔
Commanders have access to UAV data gathered in their area of operations in real-time or near-real-time form			✔
Proposed systems are capable of interchangeable or multiple payloads	✔		
Proposed systems satisfy multi-service requirements	✔		
Survivable in a high threat environment	✔		
Cost-effective	✔		
Adaptable to off-the-shelf and near future technology	✔		
Easily mobilized with few assets	✔		
Easily maintained	✔		
Have role flexibility			✔

Table 2

Since the 1960's, UAVs have come a long way in order to satisfy the criterion for effective employment on the battlefield of today. Current technology will further refine those requirements and increase UAV capability. As seen in Table 2, criterion required by commanders is and can be met by existing and prototype systems.

> The Desert Storm experience validated the concept of using Unmanned Aerial Vehicles to perform reconnaissance, surveillance, and target acquisition (RSTA) tasks on the battlefield. The Pioneer UAV systems employed by the Army, Navy, and Marine Corps elements showed that a relatively simple, inexpensive UAV system can extend the eyes of combat commanders and significantly increase combat effectiveness. Pioneer located lucrative targets which were often immediately engaged by naval gunfire, land based artillery, or close air support assets. Real time UAV imagery was then used to adjust fire on targets and to immediately assess it effectiveness. Pioneer and Joint Surveillance Target Attack Radar System (JSTARS) worked together well, demonstrating that multidiscipline cueing and target validation concepts have real applicability and value. UAV imagery was used to map the entire southern portion of Kuwait, and contributed greatly to the Marines' ability to successfully negotiate Iraqi minefields and defensive barriers with minimum damage or delay. Overall, Desert Storm confirmed the worth of UAVs in combat and provided a real world revalidation of approved needs and employment concepts.[87]
>
> Major General William H. Forster, US Army

The United States experience in Desert Storm may have provided a glimpse of the potential for momentous improvement in force capability based upon greater reliance on advanced technology. Near future technology is focusing on sensors, data processing and communications, and precision munitions, as the main areas for military exploitation. All of these areas are represented in current and follow-on lethal and non-lethal UAV technology. Overwhelming near real time combat power is the expected result of these improved technologies. Exploitation of these technological improvements requires joint integration and joint doctrinal change in order to allow the United States to

retain a decisive military advantage with the projected smaller force.[88]

Future warfare will be joint and will be fought by smaller armies. UAVs will be essential joint force multipliers in any future conflict. They survive in high threat areas, reduce risk to aircrew and ground forces, and reduce risk in politically sensitive areas. Their capabilities and payload versatility allow tactical commanders to retain a high operations tempo that will be essential to the conduct of future war. Current UAV technology represents a dramatic improvement in RSTA, EW, fire support, precision munitions, and command and control capability that especially benefit the tactical situation.

Despite improvements, there are still hurdles to clear before total capability can be extracted from UAVs for use on the battlefield. The Desert Storm experience has been a catalyst in promoting the acceptance of UAVs, though there still remains a fair amount of resistance in aviation communities.[89] Identified problem areas, such as logistics, airspace deconfliction, information dissemination and airfield requirements, are being addressed in follow on system requirements. The UAVJPO commonality and interoperability requirements have driven design of prototypes that address these problem areas.

The expected future demands of the tactical battlefield and the realities of decreasing defense budgets and forces mandate that the military community look to cost-effective force multipliers to augment declining force capability. This essay has shown UAVs to be not only cost-effective, but essential to

enhancing the combat operations of all services in future conflict. The time has come for intellectual thought and accompanying political process to ensure that UAVs can be incorporated fully into the military institution. Senior military leaders need to start the process of institutional acceptance for this revolutionary innovation.

Doctrinal integration of new technology is a decisive factor of future conflict. The military gains an advantage over an adversary by leveraging key technology.[90] Battles, campaigns, and wars are won by generating overwhelming combat power at the decisive time and place. UAVs give commanders the ability to identify that time and place and then affect operations there. They are clearly essential joint force multipliers for the future.

A rapid technological pace has been the mark of the air environment ever since the Wright brothers took to the sky in 1903. As stated by David MacIsaac in his <u>Makers of Modern Strategy</u> essay "*Voices from the Central Blue: The Airpower Theorists*" "...the effects of technology and the actions of practitioners have from the beginning played greater roles than ideas. It is even possible that we have arrived at a threshold of technological advance that may markedly change the identity of air power. Electronic combat, new satellite capabilities, precision guided munitions and pilotless aircraft suggest a new era in aviation-..."[91] It is time for senior practitioners to fully incorporate this new technology into the institution.

Annex A

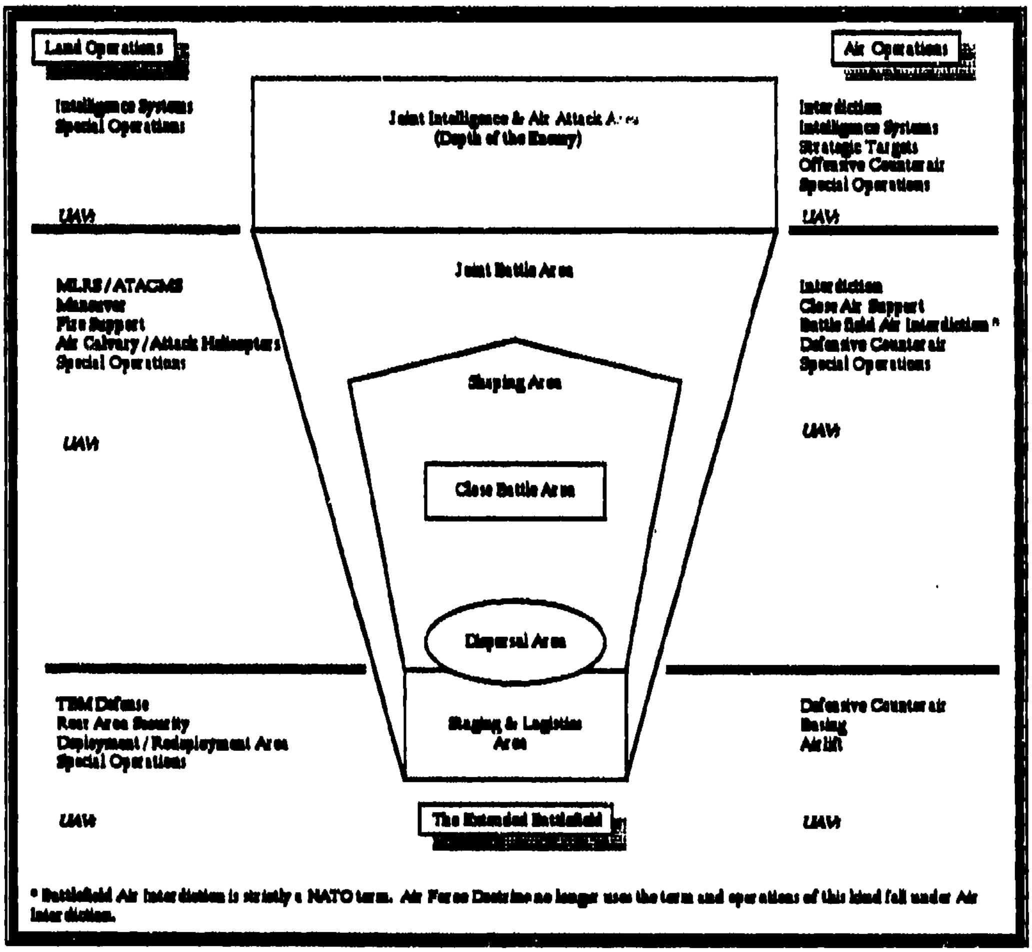

Figure 1[92]

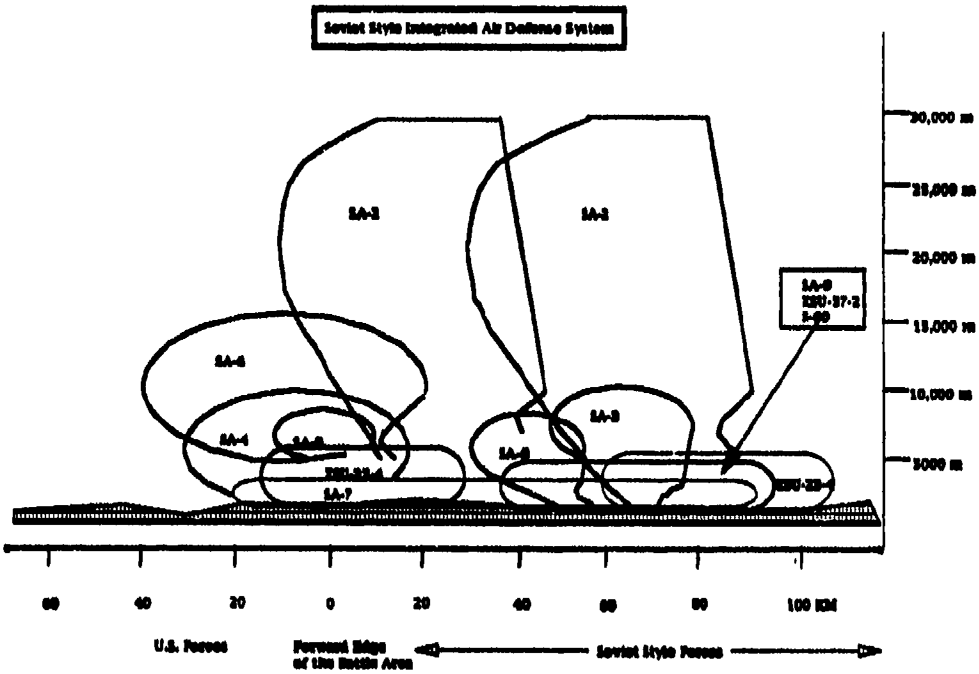

Figure 2.[93]

UAV PAYLOAD CATEGORIES

MISSIONS	PASSIVE IMAGE GENERATING SENSOR TELEVISION FORWARD-LOOKING INFRARED INFRARED LINE SCANNER	ACTIVE IMAGE GENERATING SENSOR RADARS	SPECIAL ACTIVE ILLUMINATOR SENSOR LASER DESIGNATOR	PASSIVE DIRECTION FINDER SIGNAL INTELLIGENCE ELECTRONIC SUPPORT MEASURES RECEIVER
COMMAND & CONTROL				
INTELLIGENCE	•	•		•
FIRE SUPPORT NAVAL GUNFIRE SUPPORT OVER-THE-HORIZON TARGETING ANTI-SUBMARINE WARFARE BATTLE DAMAGE ASSESSMENT	•	•	•	•
[illegible]	•	•		
AMPHIBIOUS SUPPORT	•	•	•	•
CLOSE COMBAT ASSAULT SUPPORT	•	•	•	•
AIR DEFENSE AIR CONTROL	•	•		•
MANEUVER TACTICAL MOBILITY SEARCH AND RESCUE	•	•		
TACTICAL AIR SUPPORT AVIATION SUPPRESSION OF ENEMY AIR DEFENSE AIR INTERDICTION	•	•	•	•
AIR RECONNAISSANCE COUNTER AIR	•	•		•
ELECTRONIC WARFARE				•
ANTI-SUBMARINE WARFARE SUPPORT	•	•		•
SPECIAL OPERATIONS	•			•

Figure 3.[94]

UAV PAYLOAD CATEGORIES

MISSIONS	SPECIAL PURPOSE PAYLOADS: METEOROLOGY, NBC, MINE DETECTION, ANTI-SUB WARFARE RECEIVERS	ELECTRONIC WARFARE PAYLOADS: ELECTRONIC COUNTER-MEASURES, DECOY	COMMUNICATIONS RELAY: VOICE/DATA RELAY
COMMAND & CONTROL		•	
INTELLIGENCE	•		•
FIRE SUPPORT NAVAL GUNFIRE SUPPORT OVER-THE-HORIZON TARGETING ANTI-SUBMARINE WARFARE BATTLE DAMAGE ASSESSMENT	•		•
[illegible]	•		
[illegible] SUPPORT	•	•	•
CLOSE COMBAT ASSAULT SUPPORT	•	•	
AIR DEFENSE AIR CONTROL		•	•
MANEUVER TACTICAL MOBILITY SEARCH AND RESCUE	•		•
TACTICAL AIR SUPPORT AVIATION SUPPRESSION OF ENEMY AIR DEFENSE AIR INTERDICTION	•	•	•
AIR RECONNAISSANCE COUNTER AIR	•		•
ELECTRONIC WARFARE		•	
ANTI-SUBMARINE WARFARE SUPPORT	•		•
SPECIAL OPERATIONS	•		•

Figure 4.[95]

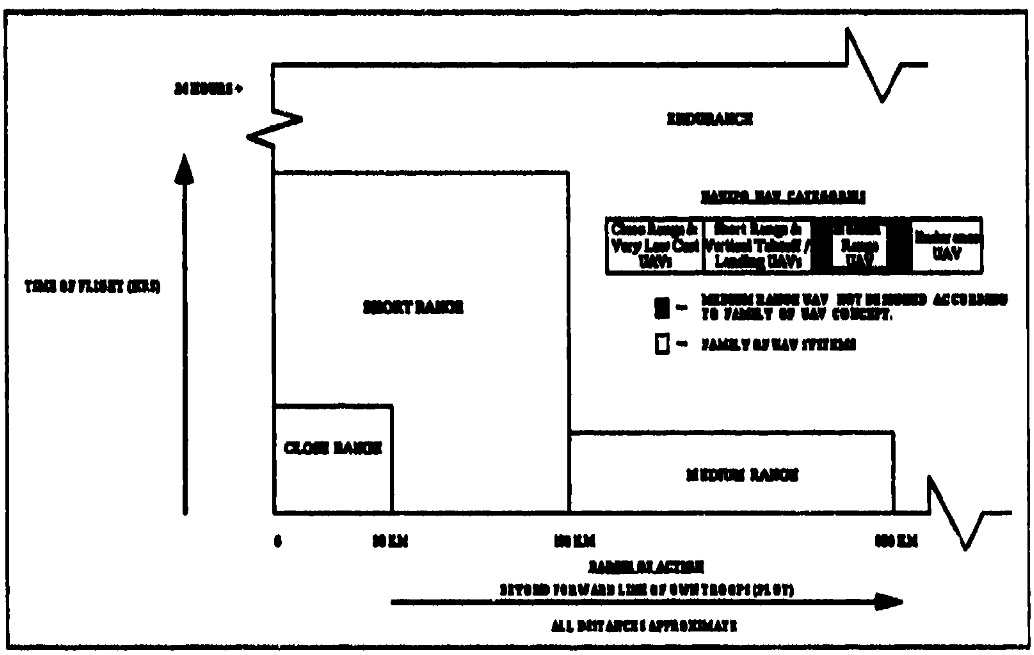

Figure 5.[96]

	CLOSE	SHORT	MEDIUM	ENDURANCE
OPERATIONAL NEEDS	RS, TA, TS, EW, MET, NBC	RS, TA, TS, MET, NBC, C2, EW	PRE AND POST STRIKE RECONNAISSANCE TA	RS, TA, C2, MET, NBC, SIGINT, EW, SPECIAL OPS
LAUNCH AND RECOVERY	LAND / SHIPBOARD	LAND / SHIPBOARD	AIR / LAND	NOT SPECIFIED
RADIUS OF ACTION	NONE STATED	150 KM BEYOND FLOT	650 KM	CLASSIFIED
SPEED	NOT SPECIFIED	DASH > 110 KNOTS CRUISE > 90 KNOTS	550 KNOTS < 20,000 FT, .9 MACH > 20, 000 FT.	NOT SPECIFIED
ENDURANCE	24 HOURS CONTINUOUS COVERAGE	8 - 12 HOURS	2 HOURS	24 HOURS ON STATION
INFORMATION TIMELINESS	NEAR-REAL-TIME	NEAR-REAL-TIME	NEAR-REAL-TIME / RECORDED	NEAR-REAL-TIME
SENSOR TYPE	DAY/NIGHT IMAGING*, EW, NBC	DAY / NIGHT IMAGING*, DATA RELAY, COMM RELAY, RADAR, SIGINT, MET, MASINT, TD, EW	DAY / NIGHT IMAGING*, SIGINT, MET, EW	SIGINT, MET, COMM RELAY, DATA RELAY, NBC, IMAGING, MASINT, EW
AIR VEHICLE CONTROL	NONE STATED	PRE-PROGRAMMED / REMOTE	PRE-PROGRAMMED	PRE-PROGRAMMED/ REMOTE
GROUND STATION	VEHICLE AND SHIP	VEHICLE AND SHIP	JSIPS (PROCESSING)	VEHICLE AND SHIP
DATA LINK	WORLD WIDE PEACE TIME USAGE, ANTI-JAM CAPABILITY	WORLD WIDE PEACE TIME USAGE, ANTI-JAM CAPABILITY	JSIPS INTEROPERABLE, WORLD WIDE PEACE TIME USAGE, ANTI-JAM CAPABILITY	WORLD WIDE PEACE TIME USAGE, ANTI-JAM CAPABILITY
CREW SIZE	MINIMUM	MINIMUM	MINIMUM	MINIMUM
SERVICE NEED / REQUIREMENT	USA, USN, USMC	USA, USN, USMC	USN, USAF, USMC	USA, USN, USMC

* BASELINE PAYLOAD CAPABILITY

LEGEND	
C2	COMMAND AND CONTROL
EW	ELECTRONIC WARFARE
JSIPS	JOINT SERVICE IMAGERY PROCESSING SYSTEM
MASINT	MEASUREMENT AND SIGNATURES INTELLIGENCE
MET	METEROLOGY
NBC	NUCLEAR, BIOLOGICAL, AND CHEMICAL RECONNAISSANCE
RS	RECONNAISSANCE AND SURVEILLANCE
SIGINT	SIGNALS INTELLIGENCE
TA	TARGET ACQUISITION
TS	TARGET SPOTTING
TD	TARGET DESIGNATOR

Figure 6.[97]

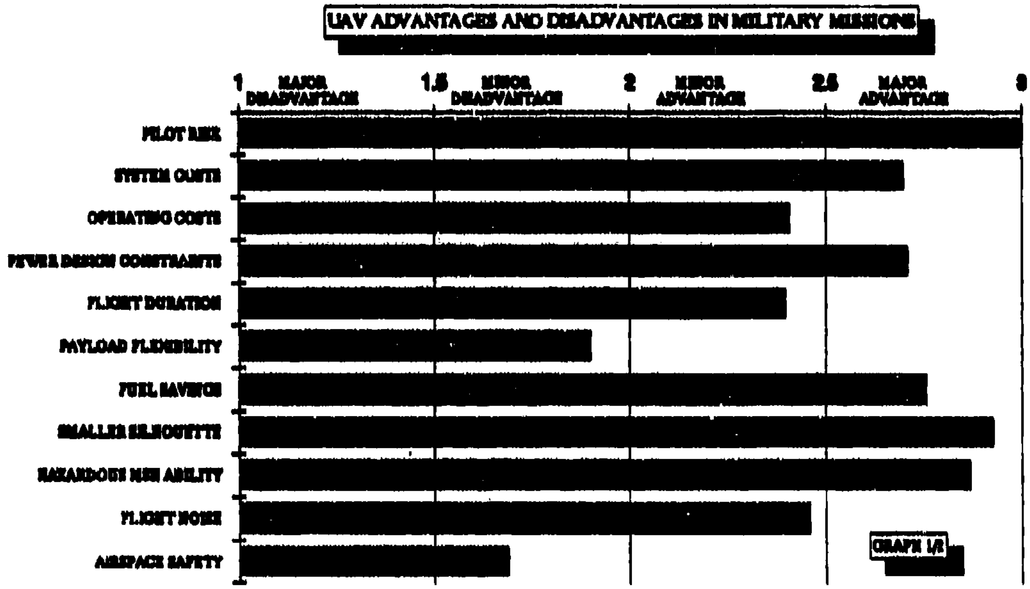

Figure 7A.[98]

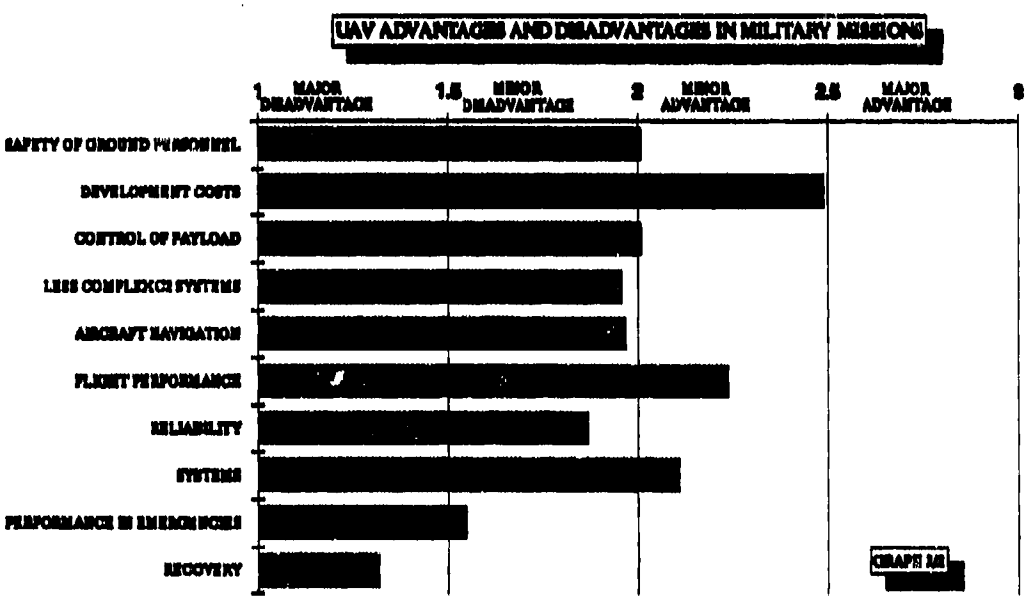

Figure 7B.[99]

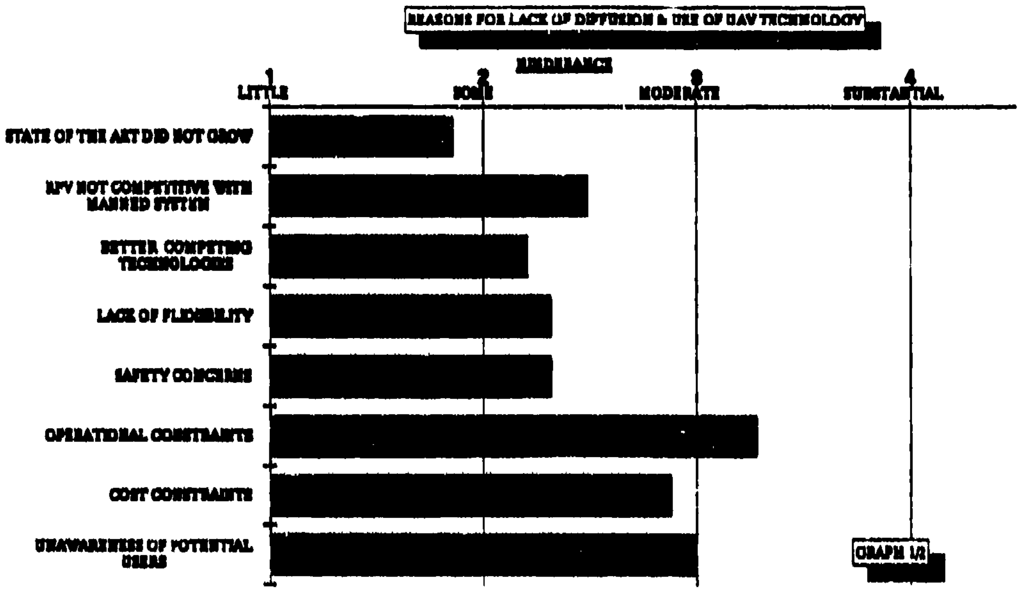

Figure 8A.[100]

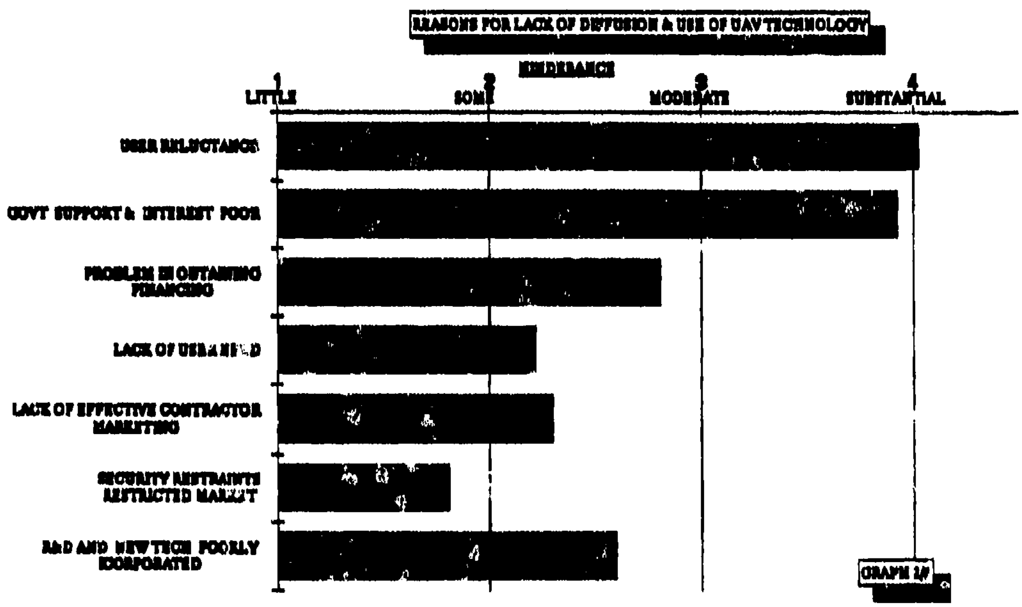

Figure 8B.[101]

Annex B

AAA - Anti Aircraft Artillery

ARM - Anti Radiation Missile

ATARS - Adavanced Tactical Air Reconnaissance System

AWACS - Airborne Warning Aircraft Control System

BDA - Bomb Damage Assessment

CBU - Cluster Bomb Unit

CR - Close Range UAV Categroy

EA-6 - Electronic Attack. Navy's standoff airborne electronic jamming platform.

ECM - Electronic Counter Measures

ECCM - Electronic Counter Counter Measures

EC-130- Electronic/Communications. Air Force airborne platfrom for disrupting enemy command, control and communications.

EF-111- Electronic Fighter. Air Force's standoff airborne electronic jamming platform.

ELINT - Electronic Intelligence

ELO - Electro-Optical

ESM - Electronic Support Measures

EW - Electronic Warfare

F/A-18- Fighter Attack Aircraft. Naval fighter, some of which are configured for reconnaissance missions.

F-4G - Air Force aircraft designed to detect, identify, locate, and destroy enemy radars.

GCI - Ground Controlled Intercept

GLCM - Ground Launched Cruise Missile

IADS - Integrated Air Defense System

IAF - Israeli Air Force

IDF - Israeli Defense Force

IMINT - Imagery Intelligence

IR - Infrared

JSIPS - Joint Service Information Processing System

JSTARS- Joint Surveillance and Target Attack Radar System

MR - Medium Range category of UAV

MISAR - Miniature Inverse Synthetic-Aperture Radar

MSAR - Miniature Synthetic-Aperture Radar

MTI - Moving Target Indicator

RF-16 - Reconnaissance Fighter. Air Force Follow-on tactical reconnaissance platform to the RF-4C

RF-4C - Reconnaissnace Fighter. Current Air Force tactical reconnaissance platfrom.

RSTA - Reconnaissance Surveillance Target Acquistion

SAM - Surface to Air Missile

SAR - Synthetic Aperture Radar

SEAD - Supression of Enemy Air Defenses

SIGINT- Signals Intelligence

SR - Short Range category of UAV

TALD - Tactical Air Launched Decoy

UAV - Unmanned Aerial Vehicle

USA - United States Army

USAF - United States Air Force

UAVJPO- Unmanned Aerial Vehicle Joint Project Office

VLC - Very Low Cost category of UAV

VTOL - Vertical Takeoff and Landing UAV

1 Steven M. Shaker & Alan R. Wise, War Without Men, (New York: Pergamon-Brassey's, 1988), p. 87.

2 DOD Joint Unmannned Aerial Vehicle (UAV) Program Master Plan- 1992, (Washington D.C.: Department of Defense, 1992), p. 64. The Program Master Plan defines unmanned aerial vehicles as a powered aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload.

3 John R. Walker, *"The Unmanned Aircraft- A Total Systems Approach"*, (NATO's Sixteen Nations, December 1990-January 1991), p. 34.

4 Sheila Galatowitsch, *"Unmanned Aerial Vehicles Take the Spotlight"*, (Defense Electronics, Vol. 23, no. 9, September 1991), p. 43.

5 Steven M. Shaker, *"Unmanned Air Vehicles"*,(Journal of Defense and Diplomacy, December 1987), p. 43.

6 Steven M. Shaker and Alan R. Wise, War Without Men, (Mclean, VA: Pergamon-Brassey's International Defense Publishers, 1988), p.27-28.

7 Steven M. Shaker, *"Unmanned Air Vehicles"*,(Journal of Defense and Diplomacy, December 1987), p. 43.

8 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April, 1981), p. 4-5.

9 Steven M. Shaker and Alan R. Wise, War Without Men, (Mclean, VA: Pergamon-Brassey's International Defense Publishers, 1988), p. 31.

10 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 7.

11 Ibid, p. 1-2.

12 Arthur Reed, Brassey's Unmanned Aircraft, (London: Brassey's Publishers Limited, 1979), p. 87.

13 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 2.

14 Chris Bellamy, The Future of Land Warfare, (New York: St. Martin's Press, 1987), p. 27.

15 Chris Bellamy, The Future of Land Warfare, (New York: St. Martin's Press, 1987), p. 27 & Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, (Santa Monica, CA: Rand Corporation, 1984) p. 4-5.

16 Colonel V. Dubrov, *Aviatsiia i kosmonavtika* (Moscow:, No. 10, October 1983), p. 46-47. Translated by Benjamin S. Lambeth, The Rand Corporation, Santa Monica California, 1984. Col Dubrov is a prominent Soviet spokesman on air warfare whose intent in this article is to impart the main tactical innovations used by the IAF and offer appropiate operational conclusions to Soviet aircrews.

17 Colonel V. Dubrov, *Aviatsiia i kosmonavtika* (Moscow:, No. 10, October 1983), p. 46-47 as translated by Benjamin S. Lambeth, The Rand Corporation, Santa Monica California, 1984 & Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, (Santa Monica, CA: Rand

Corporation, 1984) p. 7. 1) SHRIKES and Standard ARMs are anti-radar missiles designed to destroy target tracking threat radars. The MAVERICK used during this conflict was an optically guided missile that the aircrew guides from the launching aircraft using a camera in the nose of the missile as a guide. 2) The Ze'ev surface to surface missile, a lethal UAV much like the German V-1, could be fired to a range of about 40 kilometers. According to Colonel Dubrov, this was the most devastating missile of all.

[18] Chris Bellamy, The Future of Land Warfare, (New York: St. Martin's Press, 1987), p. 28.

[19] Colonel V. Dubrov, *Aviatsiia i kosmonavtika* (Moscow:, No. 10, October 1983), p. 46-47 as translated by Benjamin S. Lambeth, The Rand Corporation, Santa Monica California, 1984 & Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, (Santa Monica, CA: Rand Corporation, 1984) p. 7.

[20] Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, (Santa Monica, CA: Rand Corporation, 1984) p. 7.

[21] Brian P. Tice, *"Unmanned Aerial Vehicles: Th Force Multiplier of the 1990s"*, (Airpower Journal, Spring 1991), p. 44.

[22] Benjamin S. Lambeth, Moscow's Lessons from the 1982 Lebanon Air War, (Santa Monica, CA: Rand Corporation, 1984) p. 9-11.

[23] TRADOC PAM 525-5, Airland Operations, (Fort Monroe, VA: HQ United States Army Training and Doctrine Command, 1 August 1991), p. 15.
[24] Ibid, p. 12-13.

[25] Major General Stephen Silvasy, Jr. USA, *"Airland Operations and the Employment of Unmanned Aerial Vehicles (UAV)"*, (Unmanned Systems, Summer 1991), p. 16.

[26] *"Gulf War Experience Sparks Review of RPV Priorities"*, (Aviation Week and Space Technology, Vol 134, no. 16, 22 April 1991), p. 86.

[27] The close battle area is where the commander chooses to conduct decisive operations where as the shaping area is a defined space which is large enough to locate and develop the enemy situation and establish the conditions necessary for victory in the close battle area. These areas are created and modified by the operational commander as he synchronizes, orchestrates, and harmonizes the many activities that will result in success. TRADOC PAM 525-5, Airland Operations, (Fort Monroe, VA: HQ United States Army Training and Doctrine Command, 1 August 1991), p. 15.

[28] Theodore Deitchman, Military Power and the Advance of Technology, (Boulder CO: Westview Press, 1983), p. 52.

[29] J.D. Williams, *"Role of the Fighter Aircraft on the Modern Battlefield"*, (Canadian Defence Quarterly, Vol. 13, no.3, Winter 1983), p. 10.

[30] Arthur Reed, Brassey's Unmanned Aircraft, (London: Brassey's Publishers Limited, 1979), p. 84.

[31] *"Hope Springs Eternal for UAV Market"*, (Defense and Aerospace Electronics, Vol. 2, no. 14, 6 April 1992), p. 1-2.

[32] JCS Pub 1-02, Department of Defense Dictionary of Military and Associated Terms, (Washington D.C.: Office of the Chairman The Joint Chiefs of Staff, January 1990), p. 304-305, 365.

[33] David Fulghum, *"UAVs Pressed Into Action to Fill Intelligence Void"*, (Aviation Week and Space Technology, Vol. 135, no. 7, 19 August 1991), p. 59.

[34] David Fulgham, *"Gulf War Successes Push UAVs Into Military Doctrine Forefront"* & *"Gulf War Promts Improvements in Next Generation of UAVs"*, (Aviation Week and Space Technology, Vol. 135, no. 23, 9 December 1991), p. 39, 44.

[35] The Air Force is phasing out the RF-4C due to age and limited survival and mission capability. The last active wing of RF-4Cs, the 67th Tactical Reconnaissance Wing, is scheduled for closure in September of 1993. Two Air National Guard units will maintain RF-4C squadrons. However, the active duty force will be without a tactical reconnaissance capability until the follow-on RF-16 and Medium Range UAV is fielded. Both platforms will use the newly designed electro-optical ATARS collection package. *"U.S. Air Force Major Commands: A New Era"*, (Airman, September 1992), p. 12 & *"ATARS Payload to Fly in 1994 on Board Medium-Range UAV"*, (Aviation Week and Space Technology, Vol. 135, no. 23, 9 December 1991), p. 53.

[36] David Fulgham, *"Gulf War Successes Push UAVs Into Military Doctrine Forefront"*, (Aviation Week and Space Technology, Vol. 135, no. 23, 9 December 1991), p. 39.

[37] Tom Philpott, *"Unmanned 'toy' aided targeting, saved lives"*, (Air Force Times, 15 April 1991). p. 24.

[38] *"Operational Requirements Drive Procurement of RPVs"*, (Aviation Week and Space Technology, 28 April 1986), p. 48. Laser paths and laser munitions are more accurate when lasing occurs almost directly over the target (high angle of incidence). This reduces the laser path and reduces spillover of laser energy beyond the target, thus increasing accuracy.

[39] *"'Filtering' Helped Top Military Leaders Get Proper Intelligence Information"*, (Aviation Week and Space Technology, Vol. 134, no. 16, 22 April 1991), p. 85 .

[40] Steven Shaker, *"Saving Life and Limb and Face With Robotic Fighters"*, (Journal of Defense and Diplomacy, Vol. 9, no. 11-12, October-November 1991), p. 55.

[41] David Fulgham, *"Navy, Marine Decoy Gliders Forced Iraqi Radars to Reveal their Locations"*, (Aviation Week and Space Technology, Vol. 135, no. 7, 19 August 1991), p. 64.
[42] Ibid, p. 64-65.

[43] *"BQM-74 Drones Operated by Former GLCM Unit Played a Key Role in Deceiving Iraqi Military"* (Aviation Week and Space Technology, Vol. 136, no. 17, 27 April 1992), p. 20.
[44] Ibid.
[45] Ibid.

[46] Chris Bellamy, The Future of Land Warfare, (New York: St Martin's Press, 1987), p. 218.

[47] FM 34-1, Intelligence and Electronic Warfare Operations, (Washington D.C.: HQ Department of the Army, 1990), p. 2-16.

[48] AFM 1-1 Volume II, Basic Aerospace Doctrine of the United States Air Force, (Washington D.C.: HQ Department of the Air Force, 1992), p. 191.
[49] Ibid, p. 192.

[50] FM 34-3 Intelligence Analysis, (Washington D.C.: HQ Department of the Army, 1990), p. 1-6.

[51] Theodore Deitchman, Military Power and the Advance of Technology, (Boulder CO: Westview Press, 1983), p. 52.

[52] Robert Roy, *"Combat Operations Garner Unmanned Aerial Support"*, (Signal, April 1991), p. 17.
[53] Ibid, p. 17-18.

[54] Air Vice Marshal John R. Walker, *"The Unmanned Aircraft- A Total System Approach"*, (NATO's Sixteen Nations, Vol. 135, no. 8, December 1990-January 1991), p. 36.

[55] Tom Philpott, *"Unmanned 'toy' aided targeting, saved lives"*, (Air Force Times, 15 April 1991), p. 26.

[56] Breck Henderson, *"Boeing Condor Raises UAV Performance Levels"*, (Aviation Week and Space Technology, Vol. 132, no. 16, 23 April 1990),p. 36.

[57] DOD Joint Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 1.
[58] Ibid, p. 10.
[59] Ibid, p. 15.
[60] Ibid, p. 8-9.

[61] *"U.S. UAV Programmes: Where Do We Stand?"*, (Military Technology, No. 10, October 1991), p. 20-21. The Ex-Drone was designed to be a jamming platform but requirements in the Gulf dictated that it be converted to a RSTA platform, a conversion which limited its operational use. Caleb Baker, *"Exdrone UAV Finds Yet Another Mission: Electronic Warfare"*, (Defense News, Vol. 6, no. 3, 21 January 1991.

[62] The notional CR system consists of a small UAV capable of day/night operations. The UAV will be controlled from a portable ground station. It will require two personnel for operations and one high mobility multipurpose wheeled vehicle (HMMWV) and trailer for transport. The VLC system requires a two man team for operations and transport. DOD Joint Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 8-9.

[63] The SR UAV system consists of a mission planning control system that includes one mission planning station, two ground control stations, remote videos, eight UAVs, modular payloads, ground and air data terminals, launch and recovery equipment, and integrated logistical support. DOD Joint Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 28
[64] Ibid, p. 41.
[65] Ibid.
[66] Ibid, p. 10.

[67] Thomas G. Runge, Follow-on-Forces Attack,(Maxwell AFB AL: Air University Press, 1991), p. 54-56.

[68] The Boeings "Condor" Endurance UAV is estimated to cost $20 million dollars for the UAV alone. Payloads for the UAV, due to complexity and versatility, could double the cost of the system. This cost is far less than a satellite performing the exact same functions. Breck Henderson, *"Boeing Condor Raises UAV Performance"*, (Aviation Week and Space Technology, Vol. 132, no. 16, 23 April 1990), p. 36-37.

[69] Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 88.

[70] Wayne Stockton, *"Miniature Synthetic-Aperture Radar System (MSAR)"*, (Unmanned Systems, Vol. 9, no. 1, Winter 1991), p. 14.

[71] Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 88.

[72] Loral Defense Systems has developed a high performance low cost miniature synthetic-aperture radar for small aircraft and UAVs. Discussed in the article is the ease of combining a MSAR system

with ISAR and MTI capabiltiy. Wayne Stockton, *"Miniature Synthetic-Aperture Radar System (MSAR)"*, (Unmanned Systems, Vol. 9, no. 1, Winter 1991)

73 Unmanned Aerial Vehicle (UAV) Program Master Plan -1992, (Washington D.C.: Department of Defense 1992), p. 86.

74 "Restructure of UAV Programs Considered by Congress", (Unmanned Systems, Vol. 10, no. 3, March 1992)p. 8-9 & *"Hope Springs Eternal for the UAV Market"*, (Defense and Aerospace Electronics, Vol. 2, no. 14, 6 April 1992), p 1.

75 Anne Marie Cunningham, *"Unmanned Flying Vehicles"*, (Technology Review, Vol. 94, no. 3, Aprile 1991), p. 16.

76 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 2.

77 *"Medium-Range UAV to Help Military Narrow Tactical Intelligence Gap"*, (Aviation Week and Space Technology, Vol. 135, no. 23, 9 December 1991), p. 42-43. The SR Pioneer UAV system used in Desert Storm, consisting of four UAVs, a ground control unit, and accessories costs about $200,000. A single Pioneer UAV costs only $16,000. James Canan, "Steady Course for Unmanned Aircraft", (Air Force Magazine, March 1991), p. 87.

78 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 3.
79 Ibid, p. 14.

80 *"Superb Performance"*, (Unmanned Systems, Vol. 9, no. 3, March 1991), p. 9.

81 U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 6, 20-21.
82 Ibid, p. 20.

83 Stephen Rosen, Winning the Next War, (Ithaca, NY: Cornell University Press, 1991), p. 254.
84 Ibid, p. 258.
85 Ibid, p. 76.
86 Ibid, p. 231.

87 Major General William H. Forster, *"Systems to Meet Mission Needs"*, (Unmanned Systems, Summer 1991), p. 14.

88 Frank Kendall, *"Exploiting the Military Technical Revolution: A Concept for Joint Warfare"*, (Strategic Review, Spring 1992) p. 23.

89 Air Force and Naval aviators view UAVs as a threat to tactical manned aircraft and the Army does not like to mix manned and unmanned assets in the same airspace. Ron Schneiderman, *"Desert Storm Success Gives UAVs a Boost"*, (Microwaves & RF, March 1991), p. 47.

90 Department of the Army FM 100-5, Operations, (Washington D.C.: United States Government Printing Office, 1992), p. 2-4.

91 David MacIsaac, *"Voices From the Central Blue: The Airpower Theorists"*, (Makers of Modern Strategy, Princeton NJ: Princeton University Press, 1986) p. 647.

[92] TRADOC PAM 525-5, Airland Operations, (Fort Monroe, VA: HQ United States Army Training and Doctrine Command, 1 August 1991), p. 11, 15.

[93] David H. Cookerly, Unmanned Vehicles to Support the Tactical War, (Maxwell Air Force Base, AL: Air University, 1988), p. 10.

[94] DOD Joint Unmanned Aerial Vehicles (UAV) Master Plan - 1992 , (Washington D.C.: Department of Defense, 1992), p. 80. Chart represents service anticipated mission and payload category correlation.
[95] Ibid.
[96] Ibid, p. 9-10.
[97] Ibid, p. 8.

[98] U.S. General Accounting Office, DOD use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars, (Washington D.C.: Government Printing Office, 3 April 1981), p. 19.
[99] Ibid.
[100] Ibid, p. 21.
[101] Ibid.

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